PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/789,540
Filing Date:	February 27, 2004
Applicant:	Eric Sandstrom
Group Art Unit:	3609
Examiner:	Nicholas Kiswanto
Title:	CONCEPT FOR USING SOFTWARE / ELECTRONICS TO CALIBRATE THE CONTROL SYSTEM FOR AN AUTOMATIC TRANSMISSION
Attorney Docket:	DKT03066A (BWI-00084)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Declaration Under Rule 131(a)

Dear Sir:

Eric Sandstrom, the applicant in the above-identified patent application declares as follows:

1. That on or prior to November 4, 2002, I conceived a method of calibrating an electrohydraulic control system that provides an output response in response to an input current, said method comprising identifying a characteristic equation of the electrohydraulic system, said characteristic equation including a plurality of coefficients; coupling the electrohydraulic system to a test stand; applying a plurality of different currents to the electrohydraulic system; measuring the output response of the electrohydraulic system for each of the plurality of currents; identifying the coefficients in the characteristic equation from the output response measurements, and flashing the

coefficients in a memory the apparatus utilized with such above noted method be shown and described in the accompanying Exhibit A including a front page, and a signature page along with a witnessing page along with seven attached pages .

2. Applicant has diligently pursued such inventive method from a date on or prior to November 4, 2002 until a subsequent filing of a provisional patent application on April 11, 2003 and a further filing of a nonprovisional application claiming the benefit of the provisional application filed on February 27, 2004 evidence (Exhibit B) of such diligence is showm and demonstrated in a copy of an e-mail sent to Johannes Braum of Volkswagon, Germany wherein coefficient data regarding the invention show in Exhibit A is given.

The declarant further states that the above statements were made with the knowledge that willful false statements and the like are punishable by fine and/or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that any such willful false statement may jeopardize the validity of this application or any patent resulting therefrom.

Date: 25/Oct/07

Eric Sandstrom

P.O. Box 70098
Rochester Hills, MI 48326
(248) 364-4300

Respectfully submitted,

WARN PARTNERS, P.C.
Attorneys for Applicant

Dated: Oct 25, 2007

By:
Philip R. Warn
Reg. No. 32775

PRW:EEH:mlb

EXHIBIT A

INVENTION RECORD
BORGWARNER, INC.

BWA Case No.

Patent Dept. Use Only

Use Ink or Type

Short Title of the Invention: Concept for using software/electronics to calibrate the control system for an automatic transmission

Abstract of the Invention

Typically transmission controls require multiple mechanical adjustments (or calibrations) of the various electrohydraulic control components in order to ensure satisfactory transmission performance. Typically, each electrohydraulic component would be calibrated individually, separate from the control system. This new concept eliminates the need for mechanical calibration of individual components. In addition, it further reduces control system variation by calibrating each *function* in the system rather than calibrating individual components. The result is a less expensive, more precise control system.

Abbreviated Division Name for Invention

Calibrating Automatic Transmission Control Systems

Background Information

Attach copies of the materials, such as sketches, drawings, and descriptions, referred to in this section if possible.

1.

2.

3.

4.

5.

6.

Prior Art

Indicate the most closely related patents, publications and processes known to you.

Unknown

Related Cases

Note any related BWA case numbers (e.g. DKT92500) which you feel you may be cross-referenced to this invention.

Unknown

Detailed Description of the Invention

The calibration is achieved by generating characteristic equations that represent each basic function in the control system. The characteristic equations are written into the vehicle software stored in TCU memory and referenced each time a desired output is required from the control system. The characteristic equations are calibrated by "fitting" the characteristic curve to the actual characteristic as measured during the end-of-line test. The fitting process uses regression techniques to calculate coefficients for the characteristic equation based on measured data. The coefficients are then flashed to the TCU memory, resulting in a unique equation precisely relating desired output pressure / flow to required current.

Inventor(s)

1.	2.	3.
Eric Sandstrom Full Name (type or print)		
[redacted] Street Address		
[redacted] County		
USA Citizen of		
[redacted] Social Security No.		
[redacted] Office Phone/Office Fax		
esandstrom@afs.bwauto.com Office e-mail		
 Signature		

Witnesses

I have read and understood this **INVENTION RECORD** including 7 additional attached pages.

Signature _____ Date _____

Scott Abramczyk
Printed Name _____ Office Phone/Office Fax _____ Office e-mail _____

Signature _____ Date _____

GARY FANCHER
Printed Name _____ Office Phone/Office Fax _____ Office e-mail _____

Send Invention Record to:

Patent Department
Borg-Warner Automotive, Inc.
P.O. Box 5060
3001 W. Big Beaver Road
P.O. Box 5060
Troy, MI 48007-5060

Software Calibration - Overview

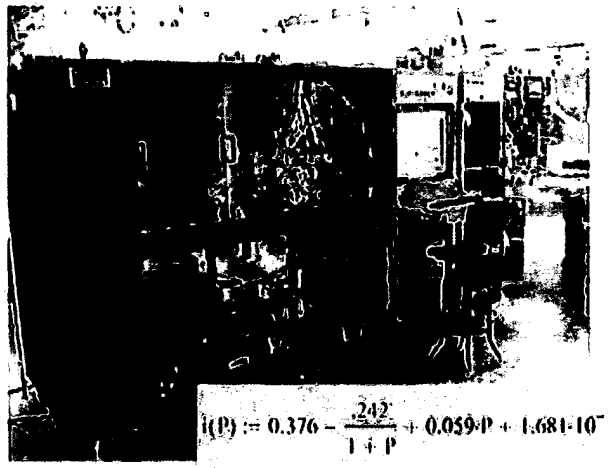
- Electronic calibration is made possible by integrated electronics (TCU)
- Electronic calibration allows
  - Increased accuracy of proportional functions
    - Improved control
    - Improved fuel economy
    - Improved driveability
  - Reduced cost

Software Calibration – How it Works

Characteristic Equation Coded into Vehicle Software

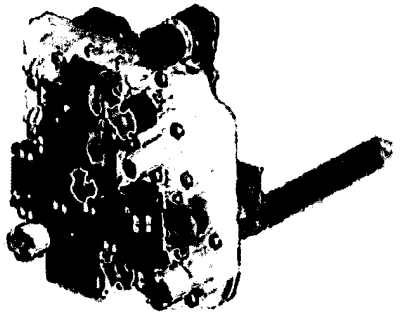
$$i(P) = c1 + \frac{c2}{1 + P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^3 + 0.0001}$$

BW Tester Calculates Coefficients During EOL Test

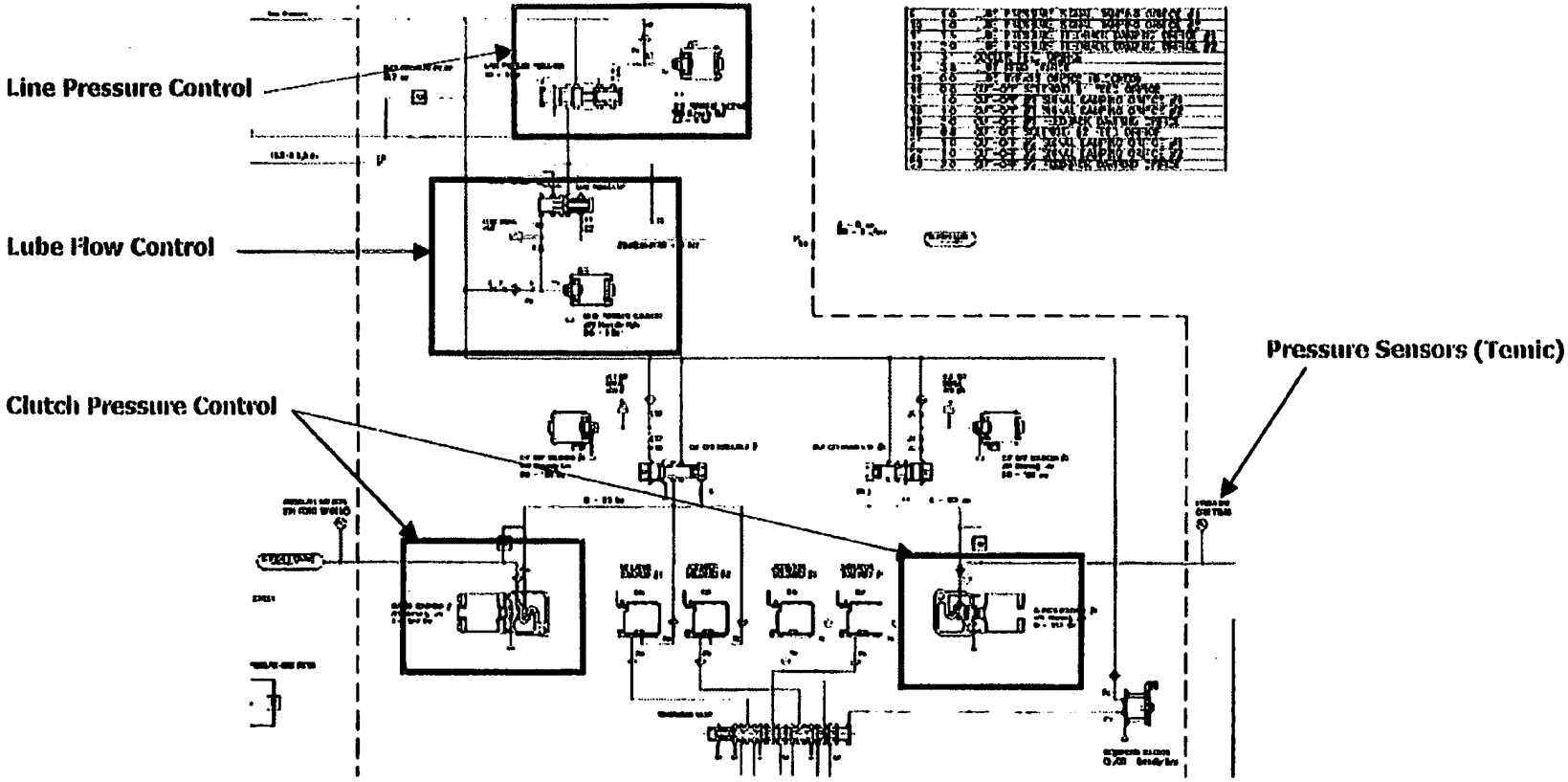


$$i(P) := 0.376 - \frac{.242}{1 + P} + 0.059 \cdot P + 1.681 \cdot 10^{-5} \cdot P^2 - \frac{7.328 \cdot 10^{-9}}{P^3 + 0.0001}$$

Calibration Data Written to TCU Memory during BW EOL Test



Software Calibration – What We Calibrate Electronically



Software Calibration – Results

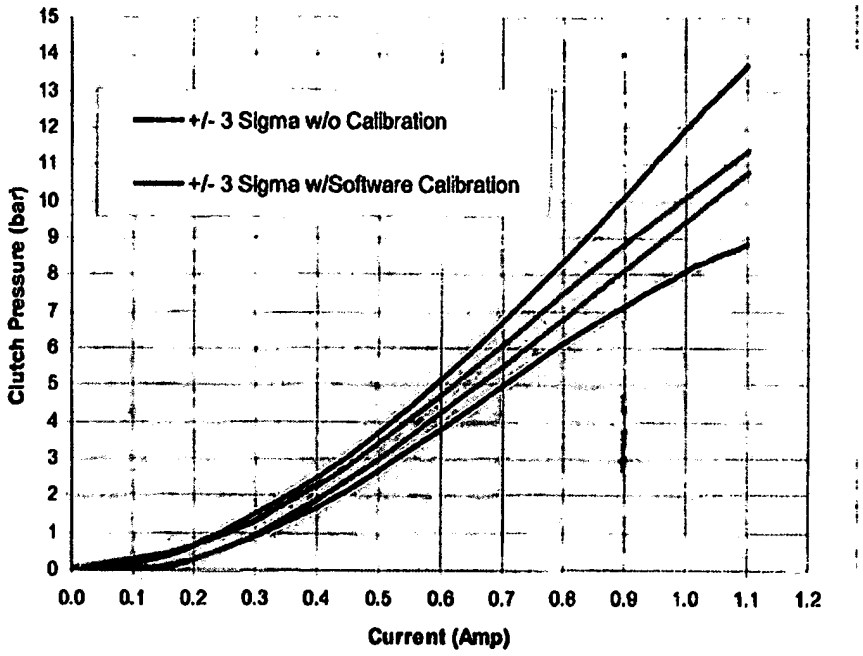
Characteristic Equation for Clutch Control

Characteristic Equation $f(P) = c1 - \frac{c2}{1-P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^2 + 0.0001}$

Sample Equation with Coefficients:

$$f(P) = 0.556 - \frac{.342}{1-P} + 0.059 \cdot P + 1.68 \cdot 10^{-4} \cdot P^2 - \frac{2.026 \cdot 10^{-4}}{P^2 + 0.0001}$$

VW DQ 250
Clutch Control Characteristic (100 pc. Sample)



Reference:D:\Program Files\MathSoft\Mathcad 8 Professional\Template\units.MCD

VW Clutch Pressure Calibration

E.C.Sandstrom

15 May 01

data := READPRN("clutch.prn")

i_data := data$^{\langle 0 \rangle}$

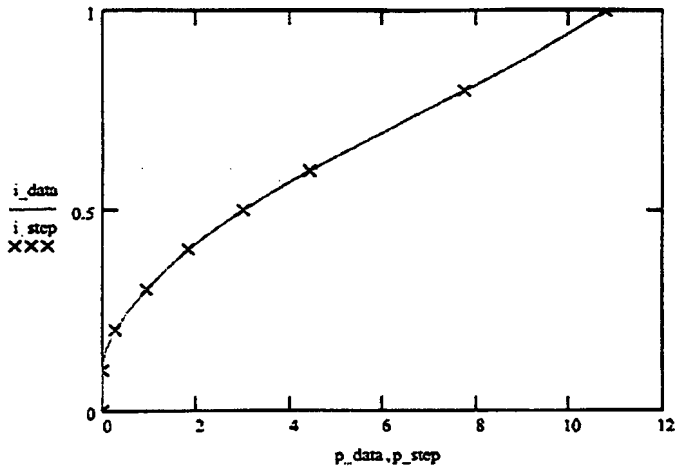
p_data := data$^{\langle 1 \rangle}$

step_data := READPRN("clutch_step.prn")

i_step := step_data$^{\langle 0 \rangle}$

p_step := step_data$^{\langle 1 \rangle}$

k := 0.. rows(data) − 1



$$F(x) := \begin{pmatrix} 1 \\ \frac{1}{1 + x} \\ x \\ x^2 \\ \frac{1}{0.0001 + x^3} \end{pmatrix}$$

n := rows(step_data) n = 9 i := 0.. n − 1

data := csort(step_data, 1)

clutch.mcd

$X := data^{\langle 1 \rangle}$ $Y := data^{\langle 0 \rangle}$ $S := linfit(X, Y, F)$

Least-squares fitting function:

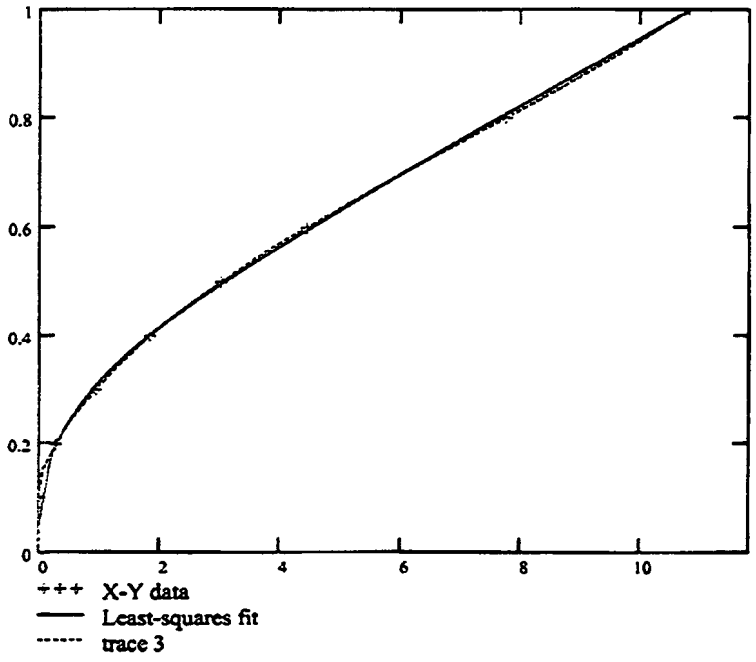
$fit(x) := F(x) \cdot S$

Sum of the squares of the residuals:

$$\sum_i \left(fit(X_i) - Y_i\right)^2 = 5.094 \times 10^{-3}$$

$npoints := 50$ $j := 0 .. npoints$

$$q_j := \min(X) + j \cdot \frac{(\max(X) - \min(X))}{npoints}$$



$P := 0, .1 .. 20$

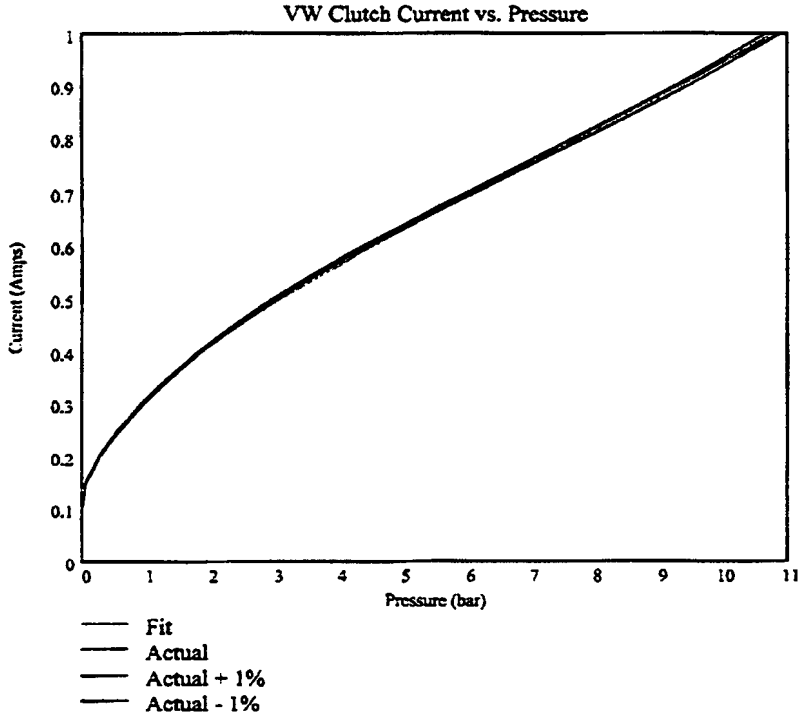
VW Clutch Pressure Calibration

E.C.Sandstrom
15 May 01

Characteristic Equation: $$i(P) = c1 + \frac{c2}{1 + P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^3 + 0.0001}$$

Sample Equation with Coefficients:

$$i(P) := 0.376 - \frac{.242}{1 + P} + 0.059 \cdot P + 1.681 \cdot 10^{-5} \cdot P^2 - \frac{7.328 \cdot 10^{-9}}{P^3 + 0.0001}$$



clutch.mcd

VW Clutch Pressure Calibration

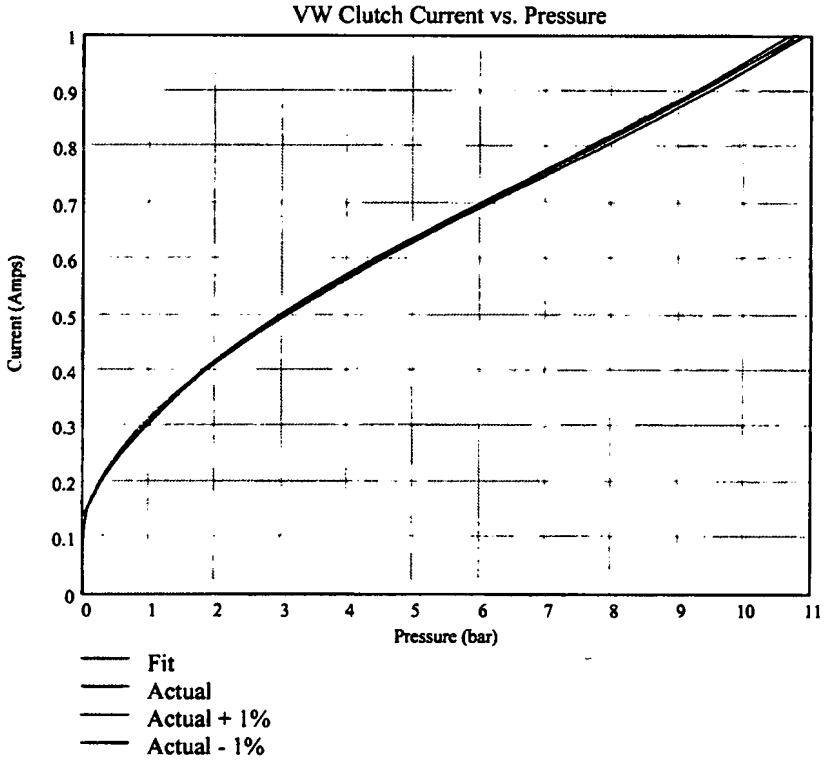
E.C.Sandstrom

15 May 01

Characteristic Equation: $$i(P) = c1 + \frac{c2}{1 + P} + c3 \cdot P + c4 \cdot P^2 + \frac{c5}{P^3 + 0.0001}$$

Sample Equation with Coefficients:

$$i(P) := 0.376 - \frac{.242}{1 + P} + 0.059 \cdot P + 1.681 \cdot 10^{-5} \cdot P^2 - \frac{7.328 \cdot 10^{-9}}{P^3 + 0.0001}$$



clutch.mcd

VW Lube Flow Calibration

E.C.Sandstrom

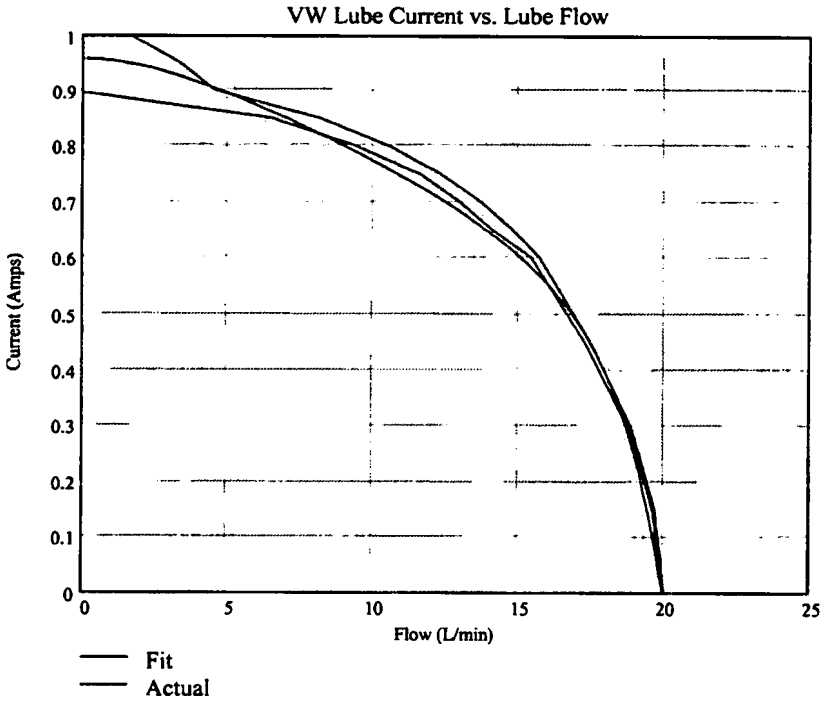
15 May 01

Characteristic Equation: $$i(Q) = c1 + c2\cdot\left(Q^2\cdot K\right) + \frac{c3}{1 + Q^2\cdot K} + c4\cdot e^{Q^2\cdot K}$$

Sample Equation with Coefficients:

$$i(Q) := 0.834 - 0.061\cdot\left(Q^2\cdot K\right) + \frac{0.123}{1 + Q^2\cdot K} - 4.958\cdot 10^{-4}\cdot e^{Q^2\cdot K}$$

where; $K = 0.017$



lube.mcd

VW Line Pressure Calibration (20 bar)

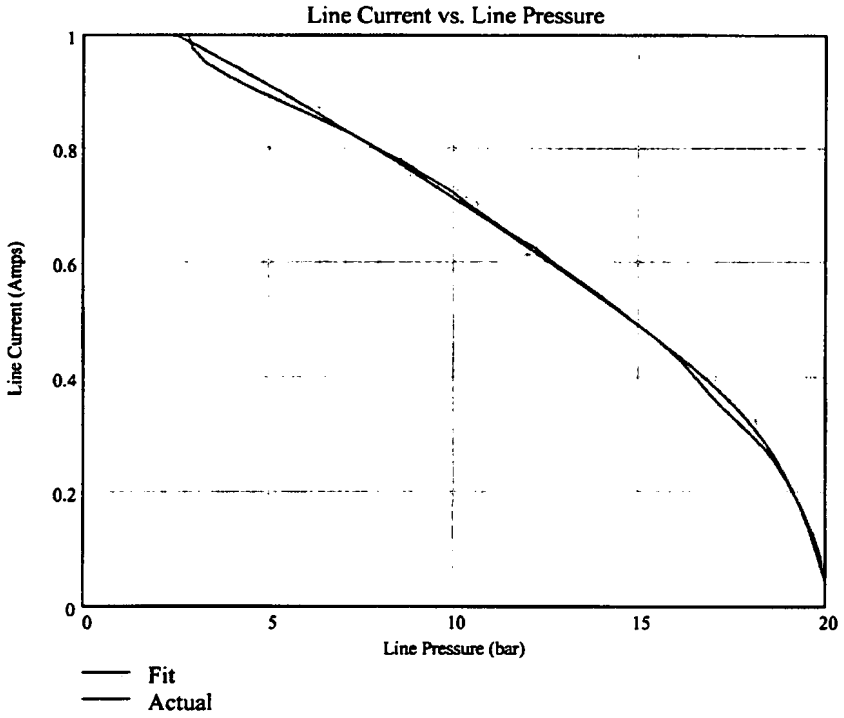
E.C.Sandstrom

10 May 01

Characteristic Equation: $i(P) = c1 + c2 \cdot P + c3 \cdot P^2 + c4 \cdot e^P$

Sample Equation with Coefficients:

$$i(P) := 1.082 - 0.032 \cdot P + -4.906 \cdot 10^{-4} \cdot P^2 - 4.231 \cdot 10^{-10} \cdot e^P$$



lp_20.mcd

VW Cut-off Valve Calibration

E.C.Sandstrom

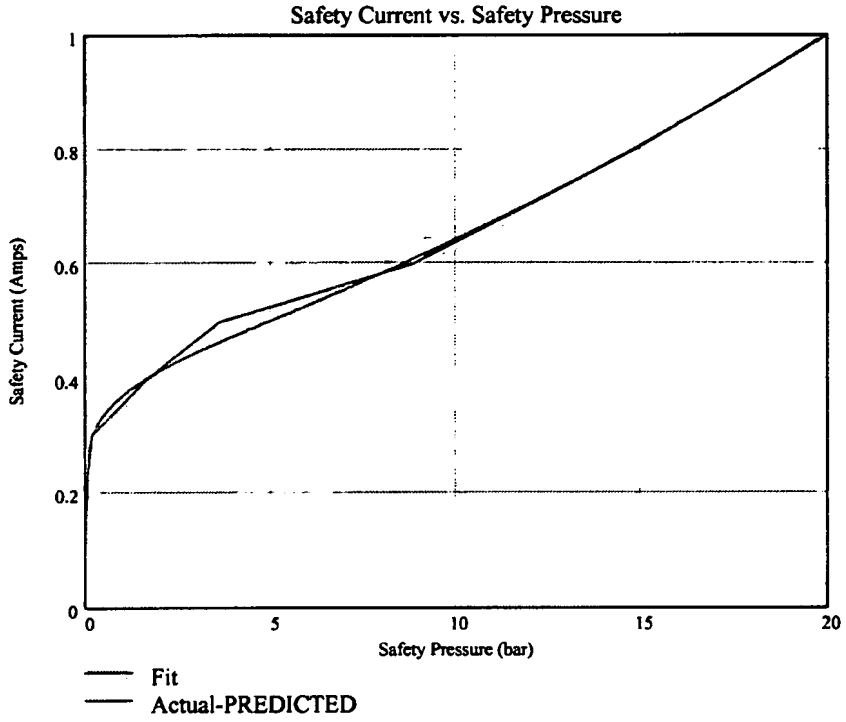
15 May 01

Characteristic Equation:

$$i(P) = c1 + \frac{c2}{1 + P} + c3 \cdot x + \frac{c4}{0.0001 + P^3} + c5 \cdot x^2$$

Sample Equation with Coefficients:

$$i(P) := 0.426 - \frac{0.15}{1 + P} + 0.017 \cdot P - \frac{1.768 \cdot 10^{-5}}{0.0001 + P^3} + 6.033 \cdot 10^{-4} \cdot P^2$$



safety.mcd

EXHIBIT B

From:
Sent:
To:
Subject: FW: VFS Data

Attachments: vfs calibration coefficients_updated_ .xls.asc

vfs calibration coefficients_u...

-----Original Message-----
From: esandstrom@borgwarner.com [mailto:esandstrom@borgwarner.com]
Sent:
To: E
Subject: FW: VFS Data

Hello E ,

Below is an e-mail that was sent to our customer (Volkswagen) back in . In the e-mail, I am sending our customer the calibration coefficients (attached) for a number of prototype samples. Basically, it is the output (c1, c2, c3, c4, c5) of the calibration routine that I'm trying to patent.

Regards,

Eric

-----Original Message-----
From: Sandstrom, Eric (PTC-Auburn Hills)
Sent:
To:
Subject: RE: VFS Data

*** PGP Decrypted Message**

Hello Johannes,

Attached is the most recent calibration coefficient sheet that I have released. I don't see the serial numbers you're looking for in my list. Tulle has started generating the coefficients for spare VFSs, so the list may have come from Tulle. You might try contacting Jean-Pierre Alexandre.

Regards,

Eric

-----Original Message-----
From:

Sent:
To: 'Sandstrom, Eric (PTC-Auburn Hills)'
Subject: AW: VFS Data

Hello Eric,
sorry, the important information (calibration data) is missing of course.
The S.N. are 02-332-001 to 02-332-023.
Attached you 'll find some (incomplete) information about our visit in Tulle (what we intend to discuss).

Regards,

J

-----Ursprüngliche Nachricht-----
Von: Sandstrom, Eric (PTC-Auburn Hills)
[mailto:ESandstrom@afs.bwauto.com]
Gesendet:
An:
Betreff: RE: VFS Data

Hello J ,

Are you looking for calibration coefficients or actual performance data?

Regards,

Eric

-----Original Message-----
From:
Sent:
To: 'BW Sandstrom, Eric'
Subject: VFS Data

Hi Eric,

you've sent an EXCEL sheet with VFS Data R7.3. I've seen it on a sheet of paper, but no one in Wolfsburg has the file. Can you send it once again?
Manufacturing date is 28th of november (332).

Regards,

J

* PGP Decrypted Message
* vfs calibration coefficients_updated_ .xls
*
*

VFS Calibration Coefficient Record for Spare Parts

Updated 12.Nov.02
Sandstrom

SN	c1	c2	c3	c4
02-211-008	3.75211040E-01	-2.99013490E-01	5.75855700E-02	1.04165450E-04
02-211-007	3.67872860E-01	-2.80711500E-01	5.99904100E-02	5.60195657E-06
02-211-004	3.67813670E-01	-2.94260380E-01	5.87849000E-02	2.09211344E-04
02-211-003	3.79844930E-01	-2.99549960E-01	5.78393300E-02	1.93211496E-04
02-211-002	3.79532040E-01	-3.16066490E-01	5.85065400E-02	3.58120571E-05
02-211-001	3.66644520E-01	-2.81361920E-01	5.79215200E-02	7.05933875E-05
02.218-004	3.55376820E-01	-2.89468280E-01	6.69475500E-02	-5.29210417E-04
02.218-003	3.69121460E-01	-2.95547230E-01	7.14677100E-02	-6.85115859E-04
02.218-002	3.75824180E-01	-3.04833530E-01	6.75222200E-02	-4.82073208E-04
02.218-001	3.52352750E-01	-2.76586580E-01	7.23954900E-02	-6.79031250E-04
02-211-010	3.94911360E-01	-3.24466150E-01	5.10883100E-02	4.82350703E-04
02-211-009	3.84860570E-01	-2.95324780E-01	5.64074900E-02	2.37089533E-04
02-218-008	3.92560980E-01	-3.34904610E-01	5.16364000E-02	4.24305972E-04
02-218-007	3.73931540E-01	-3.25813780E-01	5.75964200E-02	3.00596418E-05
02-218-006	3.82371530E-01	-3.18559890E-01	5.77502200E-02	7.70203111E-07
02-218-005	4.01369290E-01	-3.41868000E-01	5.05569500E-02	4.34254726E-04
02-245-026	3.86068130E-01	-3.17852710E-01	5.88255100E-02	5.81008370E-04
02-245-022	3.79938950E-01	-3.20029140E-01	5.67183300E-02	5.10887803E-04
02-245-021	3.71224320E-01	-2.95780430E-01	5.79418600E-02	4.23668758E-04
R7.1-02-245-20	3.81223270E-01	-3.19363910E-01	5.79049300E-02	5.08470265E-04
R7.1-02-245-19	3.79258110E-01	-3.13786110E-01	6.05554800E-02	5.60002169E-04
R7.1-02-245-18	3.75760830E-01	-3.07692860E-01	6.09615200E-02	3.60626066E-04
R7.1-02-245-17	3.66823440E-01	-2.95303180E-01	5.94944100E-02	4.88080826E-04
R7.1-02-245-16	3.75166160E-01	-3.02762980E-01	5.71469700E-02	6.38644266E-04
R7.1-02-245-14	3.89707490E-01	-3.37362450E-01	5.59110200E-02	6.78587011E-04
R7.1-02-245-13	3.86473070E-01	-3.31003410E-01	5.59996700E-02	6.91464904E-04
02-249-011	3.92280310E-01	-3.13262300E-01	5.89456200E-02	2.83273481E-04
R7.1-02-266-40	3.76533770E-01	-3.39384660E-01	5.27918600E-02	5.44180417E-04
R7.1-02-266-39	3.69236490E-01	-3.19043090E-01	5.23553600E-02	6.87916491E-04
R7.1-02-266-38	3.72744290E-01	-3.21904850E-01	5.33419400E-02	5.56955019E-04
R7.1-02-266-37	3.78213560E-01	-3.34353400E-01	5.24849500E-02	6.39299068E-04
R7.1-02-266-33	3.69053430E-01	-3.20642980E-01	5.52234100E-02	3.98842208E-04
R7.1-02-266-32	3.81208330E-01	-3.31364410E-01	5.28194600E-02	6.40472979E-04
R7.1-02-266-30	3.82303620E-01	-3.36403610E-01	5.26939900E-02	6.24639849E-04
R7.1-02-266-27	3.80918650E-01	-3.50840050E-01	5.18243900E-02	6.86545698E-04
R7.1-02-266-25	3.82819510E-01	-3.40639050E-01	5.32197100E-02	4.95574898E-04
R7.1-02-266-29	3.73505940E-01	-3.28925020E-01	5.56874100E-02	4.91779324E-04
R7.1-02-266-28	3.82622090E-01	-3.49306900E-01	5.24539600E-02	5.84046860E-04
R7.2-02-288-60	3.78312690E-01	-3.17846740E-01	5.29525000E-02	5.17406613E-04
R7.2-02-288-59	3.75114860E-01	-3.18460580E-01	5.42848700E-02	4.43207802E-04
R7.2-02-288-30	3.66452160E-01	-3.05149160E-01	5.15718000E-02	5.27025196E-04
R7.2-02-288-17	3.76575150E-01	-3.35620040E-01	5.03790500E-02	5.50725252E-04
R7.2-02-288-09	3.84295250E-01	-3.36806690E-01	5.12592200E-02	6.60437444E-04
R7.2-02-288-08	3.76094670E-01	-3.16540670E-01	5.30412900E-02	4.03713621E-04
R7.2-02-288-12	3.76329170E-01	-3.28116250E-01	5.28827800E-02	4.80152689E-04

R7.1-02-288-03	3.88418450E-01	-3.82705520E-01	5.11769500E-02	5.98520834E-04
R7.2.02.304.004	3.66749700E-01	-3.12763910E-01	4.99919700E-02	7.79768228E-04
R7.2.02.304.001	3.84879150E-01	-3.47621650E-01	5.11933700E-02	7.39841876E-04
R7.2.02.304.003	3.74308080E-01	-3.12811490E-01	5.32180500E-02	7.72372425E-04
R7.2.02.304.002	3.70840910E-01	-3.12376650E-01	5.57483400E-02	6.05354580E-04
R7.2.02.304.006	3.77888590E-01	-3.39807270E-01	5.14586300E-02	7.69310988E-04
R7.2.02.304.005	3.87355590E-01	-3.42283390E-01	5.08005700E-02	7.80789668E-04
R7.2.02.316.01	3.77786310E-01	-3.44794420E-01	5.15244200E-02	8.72466644E-04
R7.1.02.316.02	3.79142130E-01	-3.51924490E-01	5.02636300E-02	8.41898343E-04
R7.2.02.316.03	3.63458570E-01	-3.14732920E-01	5.64846700E-02	6.80343484E-04
02-310-004	3.71679540E-01	-3.42074600E-01	5.33506300E-02	5.49130392E-04
02-310-005	3.67027430E-01	-3.18055460E-01	5.65749200E-02	6.83598590E-04
02-310-006	3.79318330E-01	-3.51582860E-01	5.31259400E-02	7.39902272E-04
02-310-007	3.71718830E-01	-3.25632510E-01	5.20775100E-02	7.63472600E-04
02-310-008	3.67467920E-01	-3.41899940E-01	5.26581100E-02	6.83099704E-04

c5	Notes
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-6.91381411E-06	
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-6.60029897E-06	
-6.26644135E-06	
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-2.42792316E-06	
-3.04613288E-06	
-3.38232584E-06	
-5.61723582E-06	
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1.57719308E-06	
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2.85753746E-06	
2.43170111E-07	
6.39614730E-07	
2.74398193E-07	
3.61616143E-07	
3.19749542E-07	
2.33311358E-07	
2.24311919E-08	
4.63360907E-07	
1.40661970E-06	
6.42622956E-07	
1.19932391E-06	
-2.73222813E-06	
-2.47494511E-06	
-4.23829911E-06	
-2.59797549E-06	
-3.07237754E-06	
-2.81146489E-06	
-2.74893577E-06	
-1.48832645E-05	
-3.05348716E-06	
-2.91345819E-06	
-2.00586986E-05	
-3.06013699E-06	
-3.09810104E-06	
-3.25169334E-06	
-2.38698440E-06	
-2.90193580E-06	
-3.07394738E-06	
-2.99645407E-06	

-6.56588513E-05
-3.29342689E-06
-3.05723392E-06
-3.51089011E-06
-3.29125173E-06
-3.34527080E-06
-3.00161092E-06
-4.52066955E-06 0.8 mm orifice
-3.79376177E-06 0.8 mm orifice
-3.27646490E-06 0.8 mm orifice
-3.74575759E-06 0.8 mm orifice
-2.88599722E-06 1.0 mm orifice
-2.40078751E-06 1.0 mm orifice
-2.59177229E-06 1.0 mm orifice
-2.83247879E-06 1.0 mm orifice